



**CHEMISTRY**  
**HIGHER LEVEL**  
**PAPER 1**

Tuesday 13 November 2001 (afternoon)

1 hour

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**INSTRUCTIONS TO CANDIDATES**

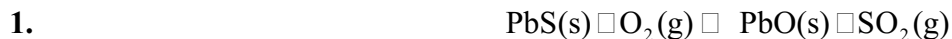
- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.

Periodic Table

1 <b>H</b> 1.01	<div>Atomic Number</div> <div>Atomic Mass</div>																2 <b>He</b> 4.00
3 <b>Li</b> 6.94	4 <b>Be</b> 9.01											5 <b>B</b> 10.81	6 <b>C</b> 12.01	7 <b>N</b> 14.01	8 <b>O</b> 16.00	9 <b>F</b> 19.00	10 <b>Ne</b> 20.18
11 <b>Na</b> 22.99	12 <b>Mg</b> 24.31											13 <b>Al</b> 26.98	14 <b>Si</b> 28.09	15 <b>P</b> 30.97	16 <b>S</b> 32.06	17 <b>Cl</b> 35.45	18 <b>Ar</b> 39.95
19 <b>K</b> 39.10	20 <b>Ca</b> 40.08	21 <b>Sc</b> 44.96	22 <b>Ti</b> 47.90	23 <b>V</b> 50.94	24 <b>Cr</b> 52.00	25 <b>Mn</b> 54.94	26 <b>Fe</b> 55.85	27 <b>Co</b> 58.93	28 <b>Ni</b> 58.71	29 <b>Cu</b> 63.55	30 <b>Zn</b> 65.37	31 <b>Ga</b> 69.72	32 <b>Ge</b> 72.59	33 <b>As</b> 74.92	34 <b>Se</b> 78.96	35 <b>Br</b> 79.90	36 <b>Kr</b> 83.80
37 <b>Rb</b> 85.47	38 <b>Sr</b> 87.62	39 <b>Y</b> 88.91	40 <b>Zr</b> 91.22	41 <b>Nb</b> 92.91	42 <b>Mo</b> 95.94	43 <b>Tc</b> 98.91	44 <b>Ru</b> 101.07	45 <b>Rh</b> 102.91	46 <b>Pd</b> 106.42	47 <b>Ag</b> 107.87	48 <b>Cd</b> 112.40	49 <b>In</b> 114.82	50 <b>Sn</b> 118.69	51 <b>Sb</b> 121.75	52 <b>Te</b> 127.60	53 <b>I</b> 126.90	54 <b>Xe</b> 131.30
55 <b>Cs</b> 132.91	56 <b>Ba</b> 137.34	57 † <b>La</b> 138.91	72 <b>Hf</b> 178.49	73 <b>Ta</b> 180.95	74 <b>W</b> 183.85	75 <b>Re</b> 186.21	76 <b>Os</b> 190.21	77 <b>Ir</b> 192.22	78 <b>Pt</b> 195.09	79 <b>Au</b> 196.97	80 <b>Hg</b> 200.59	81 <b>Tl</b> 204.37	82 <b>Pb</b> 207.19	83 <b>Bi</b> 208.98	84 <b>Po</b> (210)	85 <b>At</b> (210)	86 <b>Rn</b> (222)
87 <b>Fr</b> (223)	88 <b>Ra</b> (226)	89 ‡ <b>Ac</b> (227)	104 <b>Rf</b> (261)	105 <b>Db</b> (262)	106 <b>Sg</b> (263)	107 <b>Bh</b> (262)	108 <b>Hs</b>	109 <b>Mt</b>									

†	58 <b>Ce</b> 140.12	59 <b>Pr</b> 140.91	60 <b>Nd</b> 144.24	61 <b>Pm</b> 146.92	62 <b>Sm</b> 150.35	63 <b>Eu</b> 151.96	64 <b>Gd</b> 157.25	65 <b>Tb</b> 158.92	66 <b>Dy</b> 162.50	67 <b>Ho</b> 164.93	68 <b>Er</b> 167.26	69 <b>Tm</b> 168.93	70 <b>Yb</b> 173.04	71 <b>Lu</b> 174.97
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‡	90 <b>Th</b> 232.04	91 <b>Pa</b> 231.04	92 <b>U</b> 238.03	93 <b>Np</b> (237)	94 <b>Pu</b> (242)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (254)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (260)
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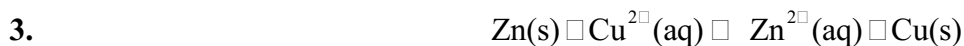


The reaction of lead(II) sulfide with oxygen at high temperatures is represented by the unbalanced equation above. What is the sum of the coefficients in the **balanced** equation?

- A. 4
- B. 5
- C. 8
- D. 9

2. 8.0 g of a pure compound contains 3.2 g of sulfur and 4.8 g of oxygen. What is its empirical formula?

- A. SO
- B. SO<sub>2</sub>
- C. SO<sub>3</sub>
- D. S<sub>2</sub>O<sub>3</sub>



Powdered zinc reacts with Cu<sup>2+</sup> ions according to the equation above. What will be the result of adding 3.25 g of Zn to 100 cm<sup>3</sup> of 0.25 mol dm<sup>-3</sup> CuSO<sub>4</sub> solution?

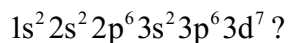
- A. All the Cu<sup>2+</sup> ions react and some solid zinc remains.
- B. All the Cu<sup>2+</sup> ions react and no solid zinc remains.
- C. All the solid zinc reacts and Cu<sup>2+</sup> ions remain.
- D. Neither solid zinc nor Cu<sup>2+</sup> ions remain.

4. Consider the composition of particles **W**, **X**, **Y**, **Z** below. Which two particles are isotopes of the same element?

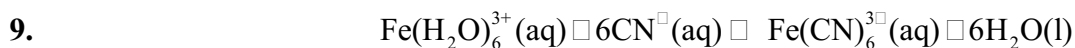
Particle	Number of protons	Number of neutrons	Number of electrons
<b>W</b>	11	12	10
<b>X</b>	12	12	12
<b>Y</b>	12	13	12
<b>Z</b>	13	14	10

- A. W and X
- B. X and Y
- C. Y and Z
- D. W and Z
5. In which of the following ground-state electron configurations are unpaired electrons present?
- I.  $1s^2 2s^2 2p^2$
- II.  $1s^2 2s^2 2p^3$
- III.  $1s^2 2s^2 2p^4$
- A. II only
- B. I and II only
- C. II and III only
- D. I, II and III

6. Which atom or ion has the electron configuration:



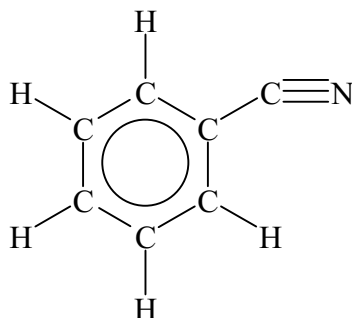
- A. Co
- B. Mn
- C.  $\text{Co}^{2+}$
- D.  $\text{Fe}^{3+}$
7. When the species Br,  $\text{Br}^+$  and  $\text{Br}^-$  are arranged in order of increasing size (smallest first), what is the correct order?
- A.  $\text{Br}^+ < \text{Br} < \text{Br}^-$
- B.  $\text{Br} < \text{Br}^+ < \text{Br}^-$
- C.  $\text{Br}^- < \text{Br} < \text{Br}^+$
- D.  $\text{Br}^- < \text{Br}^+ < \text{Br}$
8. When sodium oxide and sulfur dioxide are added to separate test tubes containing water, the solutions will be, respectively,
- A. acidic and acidic.
- B. acidic and basic.
- C. basic and basic.
- D. basic and acidic.



In the equation above the cyanide ions act as

- A. Brønsted bases.
  - B. Lewis acids.
  - C. ligands.
  - D. reducing agents.
10. The geometry and bond angle of the sulfite ion ( $\text{SO}_3^{2-}$ ) are best described as
- A. pyramidal,  $107^\circ$ .
  - B. tetrahedral,  $109^\circ$ .
  - C. bent,  $104^\circ$ .
  - D. trigonal planar,  $120^\circ$ .
11. As the size of the halogen molecules,  $\text{X}_2$ , increases down the group, their boiling points
- A. decrease due to decreasing electronegativity.
  - B. decrease due to decreasing bond energies.
  - C. increase due to increasing permanent dipole–dipole attraction.
  - D. increase due to increasing van der Waals' forces.
12. The length of the bond between carbon and oxygen is shortest in
- A. CO.
  - B.  $\text{CO}_2$ .
  - C.  $\text{CH}_3\text{CH}_2\text{OH}$ .
  - D.  $\text{CH}_3\text{CHO}$ .

13. What type(s) of hybridisation is/are used by carbon in the following compound?



- A.  $sp^2$  only
- B.  $sp$  and  $sp^2$
- C.  $sp$  and  $sp^3$
- D.  $sp^2$  and  $sp^3$
14. In which species can the bonding **not** be described in terms of the delocalisation of  $\pi$  electrons?
- A.  $CH_3CH_2O^-$
- B.  $CH_3CO_2^-$
- C.  $O_3$
- D.  $NO_3^-$
15. When the pressure is increased at constant temperature, the particles in a gas will
- A. become smaller.
- B. become larger.
- C. move faster.
- D. be closer together.

16. Which quantity will **not** change for a sample of gas in a sealed rigid container when it is cooled from 100 °C to 75 °C at constant volume?
- A. The average energy of the molecules
  - B. The average speed of the molecules
  - C. The pressure of the gas
  - D. The density of the gas
17. When solid ammonium nitrate,  $\text{NH}_4\text{NO}_3(\text{s})$ , dissolves in water, the temperature decreases. Which statement about the dissolving of ammonium nitrate in water is correct?
- A. It is endothermic with  $\Delta H$  greater than zero.
  - B. It is endothermic with  $\Delta H$  less than zero.
  - C. It is exothermic with  $\Delta H$  less than zero.
  - D. It is exothermic with  $\Delta H$  greater than zero.

- 18.
- |   |                             |
|---|-----------------------------|
| $\text{O}_2(\text{g}) \rightarrow 2\text{O}(\text{g})$    | $\Delta H = 498 \text{ kJ}$ |
| $3\text{O}_2(\text{g}) \rightarrow 2\text{O}_3(\text{g})$ | $\Delta H = 284 \text{ kJ}$ |

Using the information above, what is  $\Delta H$  for the following equation in kJ?



- A. 214
- B. 356
- C. 463
- D. 605



19. Which change leads to a decrease in entropy for the system?

- A. Solid ammonium chloride sublimates.
- B. Sodium corrodes in air.
- C. Potassium nitrate dissolves in water.
- D. Two inert gases mix at constant temperature and pressure.

20. A certain reaction is spontaneous at low temperatures but becomes non-spontaneous as the temperature is raised. Based on this information, what are the signs of  $\Delta H$  and  $\Delta S$ ?

$\Delta H$                    $\Delta S$

- A.     ☐                  ☐
- B.     ☐                  ☐
- C.     ☐                  ☐
- D.     ☐                  ☐

21. 
$$\text{Sn(s)} + 2\text{Fe}^{3+}(\text{aq}) \rightarrow \text{Sn}^{2+}(\text{aq}) + 2\text{Fe}^{2+}(\text{aq})$$

Tin metal reacts with aqueous  $\text{Fe}^{3+}$  ions according to the equation above. Which of the following factors will increase the rate of this reaction?

- I. Increasing the  $\text{Fe}^{3+}$  ion concentration
- II. Decreasing the size of the tin pieces

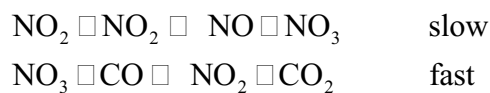
- A. I only
- B. II only
- C. Both I and II
- D. Neither I nor II

22. Use the information below to deduce the rate equation for the hypothetical reaction;



[X] / mol dm <sup>-3</sup>	[Y] / mol dm <sup>-3</sup>	Relative rate
0.01	0.01	1
0.02	0.01	4
0.02	0.02	4

- A. Rate =  $k[X][Y]$
- B. Rate =  $k[X]^2$
- C. Rate =  $k[Y]^2$
- D. Rate =  $k[X]^2[Y]^2$
23. The reaction between NO<sub>2</sub> and CO to give NO and CO<sub>2</sub> is thought to occur by the following mechanism:



What is the rate equation?

- A. Rate =  $k[\text{NO}_2][\text{CO}]$
- B. Rate =  $k[\text{NO}_3][\text{CO}]$
- C. Rate =  $k[\text{NO}_2]^2[\text{CO}]$
- D. Rate =  $k[\text{NO}_2]^2$

24. Which statement(s) is(are) correct about the effect of adding a catalyst to a system at equilibrium?

- I. The rate of the forward reaction increases.
- II. The rate of the reverse reaction increases.
- III. The yield of the products increases.

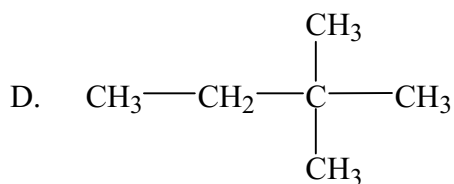
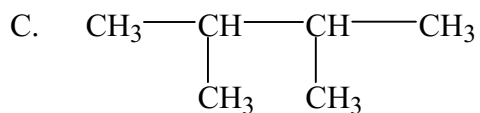
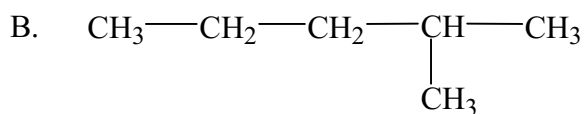
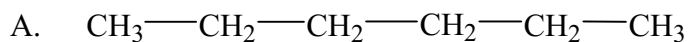
- A. I only
- B. III only
- C. I and II only
- D. I, II and III

25. 
$$\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g}) \quad K_c = 5.0 \times 10^{-3}$$

In an equilibrium mixture of these two gases,  $[\text{N}_2\text{O}_4] = 5.0 \times 10^{-1} \text{ mol dm}^{-3}$ . What is the equilibrium concentration of  $\text{NO}_2$  in  $\text{mol dm}^{-3}$ ?

- A.  $5.0 \times 10^{-1}$
- B.  $5.0 \times 10^{-2}$
- C.  $5.0 \times 10^{-3}$
- D.  $2.5 \times 10^{-4}$

26. Which of the isomers of hexane has the highest boiling point?



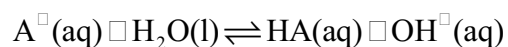
27. A Brønsted-Lowry base is defined as a substance which

- A. accepts  $\text{H}^+$  ions.
- B. produces  $\text{OH}^-$  ions.
- C. conducts electricity.
- D. donates protons.

28. A  $0.1 \text{ mol dm}^{-3}$  solution of a weak acid has a  $\text{pH} \approx 3.0$ . What is  $K_a$  for this acid?

- A.  $1 \times 10^{-1}$
- B.  $1 \times 10^{-3}$
- C.  $1 \times 10^{-5}$
- D.  $1 \times 10^{-6}$

29. The acid HA has an acid dissociation constant,  $K_a$ , in aqueous solution. What is the equilibrium constant for the reaction below?

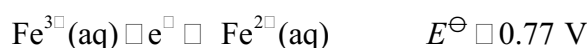
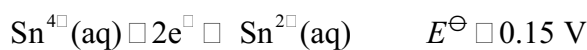


- A.  $\frac{K_w}{K_a}$
- B.  $\frac{K_a}{K_w}$
- C.  $K_a$
- D.  $\frac{1}{K_a}$
30. Which statement best describes the difference between solutions of strong and weak acids of equal concentration?
- A. Weak acid solutions have lower pH values than strong acids.
- B. Weak acid solutions react more slowly with sodium carbonate than strong acids.
- C. Weak acid solutions require fewer moles of base for neutralisation than strong acids.
- D. Weak acid solutions do not react with magnesium while strong acids do.
31. What is the oxidation number of phosphorus in  $NaH_2PO_4$ ?
- A.
- B.
- C.
- D.

32. Which of the following is **not** an oxidation–reduction reaction?

- A.  $\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{HCl}(\text{g})$
- B.  $\text{Mg}(\text{s}) + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{MgSO}_4(\text{aq}) + \text{H}_2(\text{g})$
- C.  $3\text{MnO}_4^{2-}(\text{aq}) + 4\text{H}^+(\text{aq}) \rightarrow \text{MnO}_2(\text{s}) + 2\text{MnO}_4^-(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$
- D.  $2\text{CrO}_4^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) \rightarrow \text{Cr}_2\text{O}_7^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l})$

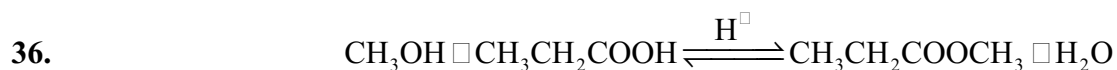
33. Use the standard electrode potentials below to determine which of the following statements is correct.



- A.  $\text{Fe}^{2+}(\text{aq})$  can spontaneously reduce  $\text{Sn}^{4+}(\text{aq})$ .
  - B.  $\text{Sn}^{2+}(\text{aq})$  is a better reducing agent than  $\text{Fe}^{2+}(\text{aq})$ .
  - C. These two half-reactions can be combined to produce a cell with  $E^\ominus = 0.92 \text{ V}$ .
  - D. The  $\text{Fe}^{3+}(\text{aq})/\text{Fe}^{2+}(\text{aq})$   $E^\ominus$  value must be multiplied by two when calculating the cell voltage for a reaction between  $\text{Fe}^{3+}$  and  $\text{Sn}^{2+}$ .
34. Two moles of electrons are passed through an electrolytic cell containing molten sodium chloride. The same charge is passed through a second cell containing aqueous sodium chloride. In both cells the electrodes are made of platinum. Which statement is correct?
- A. One mole of sodium metal will be formed in the first cell.
  - B. Chlorine gas will be formed at the cathodes of both cells.
  - C. One mole of hydrogen gas will be formed in the second cell.
  - D. One mole of oxygen gas will be formed at the anode of the second cell.

35. Which of the following is an amine?

- A.  $\text{CH}_3\text{CH}_2\text{NH}_2$
- B.  $\text{CH}_3\text{CONH}_2$
- C.  $-\text{[CH}_2\text{CONHCH}_2\text{CO]}_n^-$
- D.  $\text{CH}_3\text{CH}_2\text{C} \equiv \text{N}$



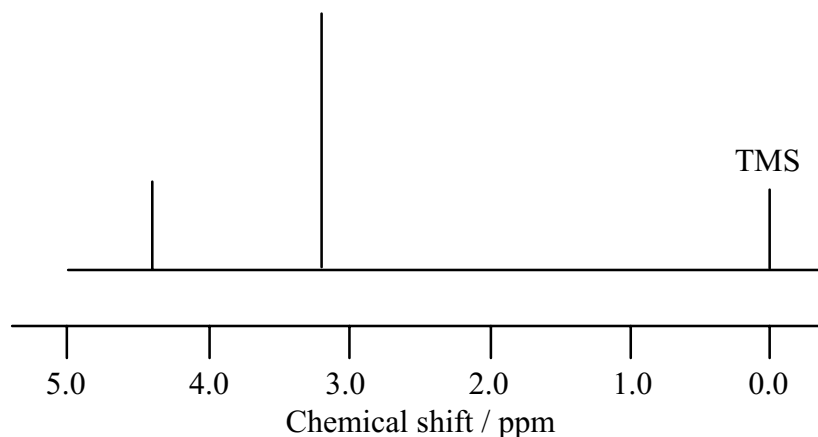
The forward reaction represented by the equation above is

- A. addition.
- B. esterification.
- C. hydrolysis.
- D. oxidation.

37. Which will be the main product when ethanol reacts with excess concentrated phosphoric acid?

- A. Ethene
- B. Methoxymethane
- C. Ethanoic acid
- D. Ethanal

38.



The low resolution  $^1\text{H}$ -NMR spectrum shown above could be given by

- A.  $\text{CH}_3\text{OH}$ .
  - B.  $\text{CH}_3\text{CH}_2\text{OH}$ .
  - C.  $\text{HCHO}$ .
  - D.  $\text{HCOOH}$ .
39. Which substance dissolves in water to give a neutral solution?
- A.  $\text{CH}_3\text{COOH}$
  - B.  $\text{CH}_3\text{COONa}$
  - C.  $\text{CH}_3\text{CH}_2\text{NH}_2$
  - D.  $\text{CH}_3\text{CONH}_2$
40. Which one of the following **cannot** be obtained by oxidising 2-methylpropan-1-ol under suitable conditions?
- A. An alkanal
  - B. An alkanone
  - C. An alkanoic acid
  - D. Carbon dioxide and water